DRAINAGE DEVELOPMENT IN THE VICINITY OF MONTEREY BAY, CALIFORNIA

BY

CHARLES NOBLE BEARD

A.B., Indiana University, 1935

A.M., Indiana University, 1936

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN GEOLOGY IN THE GRADUATE SCHOOL OF THE UNIVERSITY OF ILLINOIS, 1941

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COMMITTEE IN CHARGE OF FINAL EXAMINATION

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DRAINAGE DEVELOPMENT IN THE VICINITY OF MONTEREY BAY, CALIFORNIA

Abstract

Area, Methods of Study, and Purpose of Study

The region studied is the eastern shore of Monterey Bay and the drainage systems which discharge into it. There is no published material which deals with the geology of this region as a whole. Data for this study were derived from field investigations of physiography, structure, and stratigraphy; from pebble counts and well logs; and from laboratory analyses of sediments. Information was sought relating to the possible stages of development of the drainage and the part which the streams might have played in making the Monterey submarine canyon.

Structure

Structure map and cross sections. A structure map was constructed which showed the major fault lines, dips, anticlinal axes, and synclinal axes. Two cross sections of the northern part of the area were prepared.

The San Andreas fault. The northwest-southeast trending San Andreas fault zone dominates the structure. In many places the zone contains two or more parallel faults. Several conspicuous branch faults diverge from the main fault. Repeated strike-slip movements along the fault have produced small scarps and basins and have induced numerous landslides. The horizontal movement at Pajaro Gap, where the San Andreas fault crosses the Pajaro River, was three and one-half feet in 1906. The fault zone is often composed of many small rift valleys. In some places stream courses follow these valleys for several miles.

Dips are high in and adjacent to the fault zone, but they gradually become lower as the distance away from the fault line increases. Maximum dips of 80 degrees occur in the fault zone, but three or four miles away the dips have values of only 3 or 4 degrees.

Near Pajaro Gap there are two belts of anticlinal and synclinal axes which are parallel to the main fault zone. These belts are several miles long, and they show a considerable amount of compression.

Other major faults. On the geologic map of California compiled by Jenkins the Haywards-Calaveras fault is shown as terminating twelve miles north of Hollister. It may be however that the fault continues beneath the alluvium of the southern Santa Clara Valley and joins the San Andreas fault a few miles south of Hollister. Evidence for this is given by the logs of water wells.

A fault, known as the Sargent Oil Field fault, cuts diagonally across the southern end of the Santa Clara Valley. It follows a course parallel to the San Andreas fault line. Movements along the Sargent Oil Field fault have induced many landslides. The large "Gilroy landslide" of 1939 was adjacent to this fault line.

Fault maps made by Bruce Clark show two inferred major faults along the eastern shore of Monterey Bay. The inferred faults cross the Watsonville area in a southeast to northwest direction and connect with known faults near Santa Cruz. The writer has been unable to find any field evidence for these faults.

Stratigraphy

Sedimentary and metamorphic rocks. The age of the formations of the area ranges from pre-Jurassic to Recent. Cretaceous and Eocene rocks are not present, but all the other major subdivisions of the Mesozoic and Cenozoic areas are represented.

The Santa Lucia series of metamorphic rocks of the Gabilan Peak area near San Juan Bautista are probably pre-Jurassic. J. P. Smith suggested that they might be Paleozoic, because it was said that crinoid stems had been found in the rocks. Search by the writer revealed no fossils, but psuedo-fossils composed of nodular stalactites and banded flowstone were found.

The Franciscan formation forms the basement rock east of the San Andreas fault. Pieces of Franciscan rocks are found in nearly all the later formations throughout the area.

Oligocene, Miocene, and Pliocene rocks outcrop over wide areas in this region. The Monterey formation (Miocene) dominates the topography in the vicinity of Monterey, Santa Cruz, and Pajaro Gap. Thick soft Pliocene formations outcrop along the Pajaro River and underlie the Watsonville district. Transitional Pliocene-Pleistocene which contains both marine and fresh-water fossils is present at the south end of the Santa Clara Valley.

Quaternary formations form an important part of the geologic column in the area. Extensive gravel beds which are located north of Watsonville may be the correlative of gravel beds near Hollister. The gravel may be either Pleistocene or Plio-Pleistocene. Marine terrace deposits are widespread along the shores of Monterey Bay. In most places they are covered by Quaternary dune sands. Pebbles from alluvial deposits, which occur on terraces along the major streams, furnish indications of the former distribution of the drainage.

The igneous rocks. Intrusives form the major portion of the center of the Gabilan Range. Usually they are composed of coarse-grained gray granite, but on the north end of the mountains at Pajaro Gap there is a unique granodiorite phase of the intrusion. At the south end of the range the Pinnacles National Monument area is composed of extrusives and minor amounts of shallow-depth intrusives. The only other extrusive rocks in the region studied are on the north end of the Gabilan Range to the west of San Juan Bautista and in the southern Santa Cruz Mountains to the west of Gilroy.

Probable Stages in the Development of the Pajaro River

The Pajaro River, which drains the northern portion of the area, appears to be an antecedent stream. It has developed a canyon which is transverse to the axis of the Coast Ranges.

Marine and fresh-water fossils in beds at the southern end of the Santa Clara Valley indicate that alternate sea and lake conditions prevailed there during late Pliocene-early Pleistocene time. Whenever a lake existed, it is probable that the outlet was to the west via the Pajaro River drainage line. It would have

been easy for the ancestral Pajaro River to develop its course in the soft Pliocene formations. Movements alone the San Andreas fault line may have assisted the river in establishing its course.

During the Coast Range Revolution, presumably in early Pleistocene time, the Pajaro River probably was able to maintain its course in spite of the uplift. The river cut a deep valley during the uplift as is shown by its canyon through the Coast Ranges and by the thick fill which occurs near the mouth of the stream. Deposits of gravel were left on high level terraces east of Pajaro Gap. The gravel contains pebbles which were derived from the middle Santa Clara Valley, thus indicating that the San Benito River to the south was not yet a tributary of the Pajaro River. If a portion of the continental shelf was exposed during the uplift, the Pajaro River may have helped to excavate which is now the Monterey submarine canyon. Movements along the San Andreas fault from time to time probably produced fault breccia, and the Pajaro River picked its way through the crushed rock.

After the above events a rise of sea level or subsidence of the land caused deposition to take place throughout the course of the Pajaro River. A fill, which is shown by wells to be 200 to 400 feet thick, was made in the lower Pajaro River valley. From time to time during this period of filling the Pajaro River must have had a rather extensive delta.

The last major step was probably the gradual withdrawal of the sea to its present level. During the withdrawal Corralitos Creek, a small stream which is now tributary to the lower Pajaro River, may have built a delta or may have contributed sediment to a bar. The delta or bar probably dammed some small lateral valleys to produce five lake basins in the vicinty of what is now Watsonville. The Pajaro River abandoned parts of its channel during this period. One remnant of the former channel which is three and one-half miles long is still preserved east of Watsonville.

Various geologists have suggested that the Great Valley may have drained by way of the Santa Clara Valley and the Pajaro

River valley at some former time. Well logs in the Santa Clara Valley reveal no bedrock barrier to such a course. J. C. Branner maintained that the high level of the Coyote River fan in the middle Santa Clara Valley presented a barrier to Great Valley drainage, but the writer believes that the fan could have been built afterwards in the event that the Great Valley drainage did take a course through the Santa Clara Valley.

Elkhorn Slough and the Lower Salinas Valley

"Elkhorn Slough Valley". Elkhorn Slough occupies the mouth portion of a large valley which lies a few miles to the south of the Pajaro River. This valley was probably excavated at the same time as the Salinas Valley and at a time when the land stood higher than at present.

Well logs from the mouth of Elkhorn Slough indicate that the Salinas River and Elkhorn Slough had a common mouth during a period of fill which followed the excavation period. The mouth of the river probably continued to be in the same place until recent times, since maps show that the Salinas discharged through the mouth of Elkhorn Slough until 1908. Thick deposits of alluvium were made in the headward portion of Elkhorn Slough Valley during the filling period.

The final event in the development of Elkhorn Slough Valley was a slight uplift of the land or a lowering of sea level. This caused slight rejuvenation of the stream, and the resultant downcutting produced terraces. The present stream is small and weak and does not carry much sediment into the slough. There is evidence from the headward portion of Elkhorn Slough Valley that a part of the drainage has been captured by the San Benito River. This would account for the lessened volume of the present stream.

The lower Salinas Valley. The initial event in the development of the lower Salinas Valley was a period of excavation at a time when the land stood relatively higher than at present. Later subsidence or a rise of sea level caused a deep fill to be made. Well logs from the mouth area of the valley indicate

that the fill is more than 882 feet thick. The gravel in deep wells at Salinas is practically identical with present day Salinas River alluvium, thus indicating that the source areas for the alluvium have been the same for a long time. A layer of thick blue clay with abundant abalone shells occurs at about 165 feet below the surface in the vicinity of Salinas. This indicates that shallow water marine conditions prevailed at the time of its deposition. The final change of level in the lower Salinas Valley seems to have been a slight uplift of the land or a lowering of sea level with the result that the river cut its present deep channel.

The Salinas River probably took a prominent part in the cutting of Monterey submarine canyon provided that the shelf in the bay was ever exposed. Two points which offer evidence in support of this are: (1) pebbles taken from the axis of the canyon were similar to those found in present Salinas River alluvium and did not show any resemblance to alluvium found in the Pajaro River and Elkhorn Slough, and (2) the mouth of the river seems to have been at the head of the submarine canyon for a long period of time.

VITA

Charles Noble Beard was born near Oaktown, Indiana, December 27, 1906. He was graduated from Oaktown High School in 1924. He attended Indiana University where he received the A.B. degree in 1935 and the A.M. degree in 1936. During the year 1936-37 he was graduate assistant in the Department of Geology and Geography at the University of Illinois while carrying on graduate studies. He was instructor in geography and geology at Fresno State College from 1937 to 1939. He returned to the University of Illinois for full time graduate study from June, 1939 to June, 1940. In May, 1941 he became assistant professor at Fresno State College. He is an associate member of Sigma Xi, a member of Sigma Gamma Epsilon, and a member of the Association of Pacific Coast Geographers.

Dr. Eliot Blackwelder of Stanford University supervised field work in the Monterey Bay area in the summer of 1938, and Dr. F. P. Shepard of the University of Illinois directed similar work during the summers of 1940 and 1941. Summer term credit was granted for this work.

The writer collaborated with Dr. Shepard in the publication of "Submarine canyons: Distribution and longitudinal profiles", Geog. Rev., vol. 28, pp. 439-451. He gave a paper entiled "Occurrence and use of black sand from beaches and terraces at Monterey Bay" at the meeting of the Association of Pacific Coast Geographers in Pasadena on June 18, 1941. This paper will soon be published in the journal of the Association.